

## Thermal Fuse and Method of Manufacturing Fuse

### FIELD OF THE INVENTION

The present invention relates to a thermal fuse used for protecting  
5 various electrical and electronic appliances and electronic components, such  
as a transformer, a motor, and a secondary battery, from over-heating, and  
relates to a manufacturing method of the fuse.

### BACKGROUND OF THE INVENTION

10 Fig. 5 is a cross sectional view of a conventional thermal fuse. A  
couple of lead conductors having surface plating layers 2a formed thereon  
are connected to respective ends of fusible alloy 1 including tin through  
melting fusible alloy 1 by electrical welding or laser welding. Plating layer  
2a is composed of tin or solder which includes 60 to 65wt.% of tin and 40 to  
15 35wt.% of lead. Fusible alloy 1 is coated with flux 3 and is placed in  
tubular case 4 having openings at respective ends. The openings of case 4  
are sealed with hard resin 5.

In the conventional thermal fuse constituted as above, when lead  
conductor 2 is connected to fusible alloy 1, not only fusible alloy 1 melts, but  
20 also material of plating layer 2a having a low melting temperature melt,  
such as tin and solder, melts. The tin and lead composing plating layer 2a  
diffuse into a connection portion between lead conductor 2 and fusible alloy 1,  
and slightly changes a melting temperature of the connection portion, thus  
causing a fusing temperature of the thermal fuse to vary.

25 Variation in the fusing temperature will be explained below.

Fusible alloy 1 including tin is composed of eutectic alloy including  
63wt.% of tin and 37wt.% of lead and having a melting temperature of 183°C.

Fusible alloy 1 may have its composition changed and include an appropriate amount of indium appropriately, thus allowing the melting temperature to range from 120°C to 140°C. Fusible alloy 1 including tin and lead may include an appropriate amount of bismuth, thus allowing the melting point  
5 of the alloy 1 to range 95°C to 165°C. As above, the melting temperature of fusible alloy 1 increases if the alloy includes a large proportion of tin and lead, but the melting point decreases if the alloy includes indium and bismuth.

When lead conductors 2 are connected to fusible alloy 1 including tin,  
10 tin and lead, materials of plating layer 2a, may diffuse into both ends of fusible alloy 1, thus changing the composition at the ends of the alloy to vary and increasing the melting temperature at the ends accordingly.

#### SUMMARY OF THE INVENTION

15 A thermal fuse includes a fusible alloy including tin, a couple of lead conductors connected to both ends of the fusible alloy, respectively, and surface layers made of metal including tin provided on the lead conductors, respectively. The surface layers have thicknesses not greater than 14μm. The thermal fuse has a stable fusing temperature.

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#### BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a cross sectional view of a thermal fuse in accordance with an exemplary embodiment of the present invention.

Fig. 2 is a cross sectional view of the thermal fuse at line 2-2 shown in  
25 Fig.1.

Fig. 3 is a cross sectional view of another thermal fuse in accordance with the embodiment.

Fig. 4 is a cross sectional view of still another thermal fuse in accordance with the embodiment.

Fig. 5 is a cross sectional view of a conventional thermal fuse.

Fig. 6 shows fusing temperatures of the thermal fuse in accordance  
5 with the embodiment.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig.1 is a cross sectional view of a thermal fuse in accordance with a preferred embodiment of the present invention, and Fig.2 is a cross sectional  
10 view of the fuse at line 2-2 shown in Fig. 1. A couple of lead conductors 12 are electrically connected to respective ends of fusible alloy 11 including s tin. Lead conductor 12 has surface layer 12a having a thickness not greater than 14 $\mu$ m provided on the conductor.

Fusible alloy 11 has a substantially cylindrical shape and is made of  
15 alloy composed of tin and one of lead, bismuth, indium, cadmium, silver, and copper. Fusible alloy 11 is coated with flux 13. Fusible alloy 11 is sealed in insulating case 14 having a tubular shape and having opening portions at respective ends with hard resin 15 applied to the openings of the insulating case 14. Insulating case 14 may be made of ceramic, PBT, PPS, PPS,  
20 polyethylene-terephthalate, phenol resin, and glass. Hard resin 15 may be made of epoxy and silicon.

Lead conductor 12 is shaped like a wire and is electrically connected to each end of fusible alloy 11. The lead conductor is made of copper, iron, nickel, or alloy of them, and is plated with metal for forming surface layer  
25 12a.

Fusible alloy 11 melts by electrical welding or laser welding, and is connected to lead conductors 12. When being connected, not only fusible

alloy 11 melts, but also surface layer 12a having a low melting temperature melts.

Surface layer 12a is composed of tin, and has a thickness not greater than 14 $\mu$ m. Surface layer 12a may be composed of alloy including s tin as a  
5 main substance. The alloy is, for example, one of the follows:

(1) Dual alloy of tin and silver, for example, 95 to 99wt.% of tin and 1 to 5wt.% of silver;

(2) Dual alloy of tin and copper, for example, 97 to 99.5wt.% of tin and 0.5 to 3wt.% of copper;

10 (3) Dual alloy of tin and bismuth, for example, 96 to 99.7wt.% of tin and 0.3 to 4wt.% of bismuth;

(4) Triple alloy of tin, silver, and copper, for example, 95 to 97wt.% of tin, 2 to 5wt.% of silver, and 0.3 to 1.5wt.% of copper; and

(5) Quadruple alloy of tin, silver, copper, and bismuth, for example, 95  
15 to 97wt.% of tin, 2 to 4wt.% of silver, 0.3 to 1.5wt.% of copper, and 0.3 to 1wt.% of bismuth.

The alloy decreases the melting temperature of surface layer 12a. Composition for decreasing the melting temperature of surface layer 12a allows lead conductor 12 to be easily connected to fusible alloy 11 and  
20 soldered to a mounting board and other leads.

Variation of fusing temperatures of the thermal fuse in accordance with the embodiment and comparative examples of a conventional thermal fuse was measured under the condition of various surface layers 12a having various compositions and thicknesses.

25 Ten samples for each thermal fuse were prepared. Fusible alloy 11 was composed of tin, lead, and bismuth, had a melting temperature of 98°C, and had a diameter of 0.6mm and a length of 4mm. Lead conductor 12 was

made of copper and had a diameter of 0.6mm. Flux 13 was a type of rosin. Insulating case 14 was made of ceramic. Hard resin 15 was made of epoxy resin.

All the samples were put into an oven at an oven temperature of 78°C.

5 The oven temperature was raised by 1°C per minute, and have their fusing temperatures measured. Resultant measurements are shown with Fig. 6.

As shown in Fig. 6, the fuses of the embodiment having surface layers 12a of tin plating or alloy plating which includes tin as main substance having the thickness not greater than 14μm have small variations of the  
10 fusing temperatures, while the comparative examples of the fuses have larger variations of the fusing temperatures than the fuses of the embodiment.

As described above, in the thermal fuse of the embodiment, surface layer 12a of one of thin tin plating and alloy plating which includes tin as the  
15 main substance having the thickness of 14μm or less is provided on lead conductor 12. When lead conductor 12 is electrically connected to fusible alloy 11 including tin, variation of the composition at the ends of fusible alloy 11 is reduced even if tin in surface layer 12a diffuses into fusible alloy 11. Therefore, the thermal fuse has a stable fusing temperature.

20 If surface layer 12a is thinner than 1μm, inconsistency and oxidation which includes tarnishing in the plating are accelerated, thus reducing wettability of the surface layer. This makes lead conductor 12 hard to be connected to fusible alloy 11 and be soldered to an outside object. In order to reduce diffusion of materials of surface layer 12a as much as possible,  
25 length B of a connection portion between fusible alloy 11 and lead conductor 12 is controlled to be not greater than 1mm.

Surface layer 12a composed of tin or the metal which includes tin as the

main substance is provided on lead conductor 12 by a hot-dip plating method or an electrical plating method. Surface layer 12a formed by the hot-dipping method has orientation of composition of metal less than surface layer 12a formed by the electrical plating method, thus having a larger wettability of metal. Lead conductor 12 can be accordingly connected to fusible alloy 11 easily and soldered to the outside object easily. The orientation of the metal composition can be reduced to a certain extent by performing a heating process after electrical plating, thus increasing the wettability. In order to have the wettability better, metal particles of surface layer 12a be preferably controlled to be not greater than  $10\mu\text{m}$ .

Surface layer 12a from the connection portion between lead conductor 12 and fusible alloy 11 may have a length such that a portion having the length where surface layer 12a melts and diffuses into fusible alloy 11 changes the composition of each ends of fusible alloy 11 when lead conductor 12 is connected to fusible alloy 11.

In the embodiment, the thermal fuse, which is of an axial lead type having a couple of lead conductors 12 linearly arranged is explained. The fuse may be of a radial-lead type as shown in Fig.3. The fuse of the radial-lead type has a couple of lead conductors 112 shaped like wires arranged in parallel to each other. Lead conductor 112 has surface layer 112a similar to surface layer 12 of the embodiment, thus providing the thermal fuse with effect similar to that of the embodiment. Technique of the embodiment can be applied to a thin thermal fuse shown in Fig. 4. The thin thermal fuse shown in fig. 4 has a couple of lead conductors 22 shape in plate arranged linearly, and the technique of the embodiment can be applied to the thin thermal fuse.